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3/25/64	Mk 57 Mod 1 Bomb, incorporating radio-frequency filter pack, design released.
5/64	Early production of Mk 57 Mod 1 Bomb.
9/16/64	Mk 57 Mod 2 Bomb, incorporating prescribed action link, design released and production achieved.

(b)(1), (b)(3)

11/65	Early production of Mk 57 Mod 3 Bomb.
12/65	Early production of Mk 57 Mod 4 Bomb.
6/2/66	Mk 57 Mod 5, providing compatibility of Mk 57 Mod 1 Bomb with B-52 aircraft, design released. Mk 57 Mod 5, providing compatibility of Mk 57 Mod 3 Bomb with B-52 aircraft, design released.
9/66	Early production of Mk 57 Mod 5 Bomb.
10/5/66	Mk 57 Mod 2 Nose, with improved impact characteristics, design released.
11/66	Early retrofit of Mk 57 Mod 3 to Mk 57 Mod 4 Bombs.
12/66	Early production of Mk 57 Mod 2 Nose.

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that with minor exceptions the current design met or exceeded LITTLE LULU requirements.[12] Subsequently, the Navy accepted a proposal that the Atomic Energy Commission assume full responsibility for both nuclear and nonnuclear portions of the bomb.[13]

Nomenclature of TX-57 was assigned to the program in December 1959. The bomb would provide a single configuration compatible with the greatest practicable number of delivery modes and aircraft. There would be five fuzing options: Retarded depth bomb, retarded laydown, retarded air burst, free-fall air burst, and possibly free-fall contact.

The depth-bomb option would be selected prior to takeoff.

(b)(1), (b)(3)

Free-fall or retarded methods of delivery would be chosen prior to takeoff, but air or surface-burst options would be selected during flight.[14]

Meanwhile, detail design was continuing. Explosive components, then under intensive development, were attractive from the standpoints of small size and simplicity of operation, and much attention was given to such design.

(b)(3)

The final decision was to use a chopper-converter system in combination with electronically timed external initiation.

There were several possibilities for design of X-unit energy switching circuits, and an explosive tack switch was given consideration over a trigger circuit-gap combination. Its one-shot operation, which resulted in a nontestable firing set, was a deterrent, but this was not an overwhelming obstacle, as all other components could be adequately tested. The past history of squib-operated devices in performing switching functions, their simplicity of operation, the existence of four independent inputs providing redundancy of circuits, the wide latitude of inputs which the system could accept, and the large number of tests that would be performed before the system would be used, all contributed confidence to the tack-switch design.[15]

The military characteristics for a lightweight, multipurpose nuclear depth charge/bomb were approved by the Military Liaison Committee December 22, 1959. A design goal was that no maintenance or functional testing of components would be required of the using agency of the Atomic Energy Commission.

(b)(3)

The weapon would have the minimum length required for good underwater and air trajectories, and a maximum weight of 500 pounds. It would be capable of either single or multiple carriage and release under operational conditions from a wide range of Navy aircraft, including the S2F-1, S2F-3, P5M-1, P5M-2, P2V-5, P2V-7, HSS-1, HSS-1N, HSS-2, DSN-2, DSN-3, P3V, ZS2G1, A2F, A3D-1, A4D-2, A4D-2N, A3J, F4H, FJ-4B, AD-5N, AD-6 and AD-7.

(b)(1), (b)(3)

Antisubmarine warfare application required release of the bomb at airspeeds from 0 to 400 knots and altitudes between 30 and 1000 feet, and the weapon would have to enter the water without ricochet.

(b)(1), (b)(3)

Laydown applications required aircraft release at airspeeds from 130 knots to Mach 0.95 and altitudes between 50 and 2000 feet. Delivery would be possible on water, soil, concrete and typical airfield runway construction. The weapon would not penetrate earth or concrete to the extent that it would degrade blast, radiation or thermal effects. Any target impact would result in minimum ricochet.

(b)(3)

Delivery modes included level flight, dive, loft, over-the-shoulder toss, glide and roll-ahead.[16]

The military characteristics were forwarded by the Division of Military Application January 6, 1960.

(b)(1), (b)(3)

The operational availability date would be no later than July 1962. It was suggested that the nuclear program be assigned to Los Alamos, and it was noted that the Department of Defense had requested that a tested nuclear design be used.[17] The military characteristics did not include a requirement for a free-fall contact-burst option, and work in this area was discontinued.[18]

By January 1960 three problems were being investigated: High impact shock associated with laydown, water-entry shock of the depth bomb, and underwater ballistics and fuzing. It had been decided that several new fuzing components would have to be developed. These included the following: A pyroelectric switch to perform one-shot switching functions; a switch to provide delayed parachute deployment when the bomb was carried internally in aircraft; a fixed interval timer for both laydown and depth-bomb fuzes; an adjustable timer for parachute deployment, trajectory arming, and safe separation; a delayed option switch to function as a latching device in trajectory arming; a differential pressure switch which, when used with an aerodynamic fence, would close above an airspeed of 180 knots and open below 130 knots; a setback switch, which would close above 1.6 g's and open below 1.2 g's; a 3-position, motor-driven switch, providing selection of safe, ground or air options; a parachute jettison explosive actuator producing about 2400 pounds force over a stroke of about 1-1/2 inches; a parachute deployment gas generator that would develop about 10,000 foot-pounds of energy; and a low-voltage thermal battery, hydrostat and sink-rate switch for the depth-bomb option.[19]

A Technical Project Officer Group for the TX-57 was formed and initially met January 26, 1960.

(b)(1), (b)(3)

(b)(1), (b)(3)

By late March 1960, data on overpressures created by underwater bursts had been collected and safe-escape requirements for the TX-57 had been revised.

(b)(1), (b)(3)

The kill probability of this simplified system was felt to be only slightly less than a more complex system using a sink-rate switch, and development of this latter component was canceled.[21]

(b)(1), (b)(3)

Since the bomb would have a chopper-converter charging system, maximum safety could be achieved through isolation of the low-voltage power source, rather than by removal of a component of the high-voltage system.

(b)(1), (b)(3)

The Division of Military Application had requested that, if possible, the development time scales of the bomb be shortened. Sandia replied by teletype, May 31, 1960, noting that components for the depth-bomb option controlled the time schedule, and that the bomb could not be made available earlier than the scheduled date of July 1962.[23]

low-voltage circuit would prevent this circuit from becoming energized if the weapon became exposed to a fire that could activate the thermal batteries. Trajectory sensing devices would be incorporated.

The drop-test program was proceeding, with several drops having been completed. These provided aerodynamic information and demonstrated case strength for laydown applications.

(b)(3) Two successful parachute-ejection laboratory tests had been conducted.

No unusually troublesome procurement or manufacturing problems were anticipated, with the possible exception of hydrostats for the depth-bomb option and a turbogenerator power supply for the radar. The hydrostat was a new item, and there had been limited experience with turbogenerator power supplies.[26]

An amendment to the military characteristics was released by the Military Liaison Committee August 19, 1960.

(b)(1), (b)(3)

A meeting was held August 29, 1960 to discuss the number of hydrostats needed for the weapon system.[29] To nullify the effects of hydrostat contact chatter during parachute jettisoning, a 7-second time delay had been introduced into the hydrostat circuit.

(b)(1), (b)(3)

Work was under way on the design of the trajectory arming system. Initially, little military information was available on bomb delivery capabilities. In ensuing discussions, it was decided that all normal Navy and Air Force tactical aircraft, including the AD series, would be considered as carriers for the laydown, retarded-air-burst, and free-fall options; and the P2V, S2F and P5M series aircraft and a hovering helicopter were selected for depth-bomb delivery. Delivery parameters were then established.

(b)(1), (b)(3)

(b)(1), (b)(3)

For the retarded air-burst option, the original arming system was retained.

(b)(1), (b)(3)

A circuit was designed that enabled the parachute-jettison circuitry at the instant the weapon velocity was sufficiently reduced. This allowed the velocity sensing system to be used for parachute jettison at water entry.

Wind-tunnel tests were conducted on the full-scale weapon and showed that the pressure at the velocity sensing ports fluctuated. This resulted in a wider operating tolerance range and produced chatter of the differential pressure switch. The chatter caused parachute deployment while the bomb was still in the air portion of its trajectory and affected proper depth-bomb operation.

Since the AD-series aircraft were listed as desired but not required carriers, the Bureau of Weapons was asked if these aircraft could be deleted.

(b)(1), (b)(3)

The trajectory arming system was designed on this basis and accepted.

Subsequently, however, the Navy objected to increasing the speed for laydown releases, and requested that the AD capability not be deleted. A system was designed to meet all the requirements of the military characteristics and provide all the requested delivery capabilities.

(b)(1), (b)(3)

In the depth-bomb option, the velocity sensing system was used to provide water entry and parachute jettisoning signals.

(b)(1), (b)(3)

The Navy also felt that antisubmarine-warfare aircraft should have laydown delivery capability.

(b)(1), (b)(3)

It was felt that all Navy tactical aircraft should be able to deliver the weapon in the depth-bomb option.[31]

(b)(1), (b)(3)

As recent information from Sandia had indicated that the pressure differential switch would not function properly at this airspeed in the free-fall-option mode, comments were requested on the effect of deleting the free-fall requirement.[32]

(b)(1), (b)(3)

However, reduction of the minimum delivery-speed requirement in the free-fall option was difficult.

(b)(1), (b)(3)

This would increase the bomb weight, and would require from 4 to 5 months of design time.

Sandia noted that elimination of the free-fall option would produce significant weapon gains. This change would simplify the design, possibly eliminate an aft set of stabilizing fins, reduce weapon weight, provide a favorable shift in center of gravity, and significantly reduce weapon cost.

(b)(1), (b)(3)

(b)(1), (b)(3)

Field Command subsequently reported that the Navy and Air Force agreed to increasing the minimum release speed of the helicopter.[38]

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The Mk 57 Mod 0 was design released in [illegible] 1961. The bomb would be stockpiled in two configurations: Mk 57 bomb with Mk 57 Mod 0 Nose, and Mk 57 bomb with Mk 57 Mod 1 Nose. The Mod 0 Nose was used in the retarded depth bomb and retarded laydown options, and formed a ballistic nose for the bomb. The Mod 1 Nose would contain a radar and be used in the retarded-air-burst and free-fall air-burst options. The two noses would be interchangeable in the field. Early production occurred in January 1963.[39]

(b)(1), (b)(3)

This latter component was subsequently incorporated into the bomb in the fall of 1963 as Alt 243.[41]

By mid-1962, difficulties were being encountered with explosive switches, which did not function in a reliable manner.[42] Since there were 36 of these components in each weapon, this was a matter of some concern, and it was decided that early bomb production would be delayed from June 1962 to February 1963. Active development of this switch had started in September 1959 and, some 6 months later, a substantial number of switches had been received from the manufacturer and tested. These performed satisfactorily, although some evidence of high contact resistance was noted. However, this was attributed to dirty parts discovered during postmortem examination.

It was decided that an adequate seal should be developed to exclude this dirt, and a contract was placed with the manufacturer. The first models of the new design performed well but, by mid-1961, a statistically significant number of switches showed residual resistance, after firing, of less than the 100 ohms specified. The propellant charge was changed to a material whose resulting ash was nonconductive, and solved this problem.

The component was design released in August 1961 after 240 development switches had been built and fired successfully. Production assembly was started, but a major

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(b)(1), (b)(3)

At release plus about 0.08 second (fast) or 0.8 second (delayed), parachute deployment was initiated. Trajectory arming occurred when the retardation furnished by the parachute caused an inertial switch to close for enough time to allow the trajectory arm switch to operate. This inertial switch remained open below 5 g's and closed above 6.2 g's. The trajectory arm switch closed when the power driving it was applied for at least 0.25 second.

Within 3 seconds after release, the 28-volt section of the thermal battery came up to voltage, starting a set of chopper motors and disabling the 12-volt circuits, thus isolating the aft case circuitry from the power supply. About 25 seconds after release, the sequential timer provided a fire signal that discharged the X-unit and initiated the neutron generators, detonating the weapon.

Retarded-air-burst operation was similar to the foregoing, except that the burst-height switch was placed at either HIGH or LOW, and the desired safe-separation time set on the trajectory/safe-separation timer. In flight, the aircraft monitor and control power was turned ON, and the selector switch set to AIR. Pulse battery and timer were again initiated at release and, if a long safe-separation time had been selected, a pulse pin actuated a transfer switch in the weapon which opened the short-time circuit.

(b)(3)

Parachute deployment was initiated as previously described, and trajectory arming took place under the proper conditions. When the trajectory/safe-separation timer closed, a signal was provided for charging the X-unit and enabling the radar fire line. At the desired burst height, the radar provided a firing signal, causing the X-unit to discharge, initiating the neutron generators and firing the weapon detonators.

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bomb was still in the air.

(b)(1), (b)(3)

The chopper motors started to operate as thermal-battery voltage rose. At water entry, the pressure switch closed due to differential water pressure across the faces of the differential pressure inducer. This provided a water-entry signal that fired a detonator to jettison the parachute, enabled the 28-volt depth-bomb circuits, started the sequential timer, and disabled the 12-volt circuits.

(b)(1), (b)(3)

The 7-second timer prevented premature arming resulting from momentary hydrostat closure at water entry or from bottom impact in shallow water.

(b)(1), (b)(3)

Some radars incorporated solid-state devices and were identified as Mk 57 Mod 1 Alt 7[illegible] Boxes. This Alt contained a thermal battery, series regulator, magnetic chopper, and full-wave bridge with filter.

(b)(1), (b)(3)

(b)(1), (b)(3)

Field Command -- The local office of the Armed Forces Special Weapons Project (Defense Atomic Support Agency), located on Sandia Base, Albuquerque, New Mexico.

Firing System -- The electrical system of the weapon that produces and applies a high-voltage current to the detonators.

Free-Fall Bomb -- A bomb that falls under the forces of gravity and the impetus given at time of release.

Fuzing System -- The system that arms the weapon at the appropriate time and provides a firing signal to the firing system at the selected burst height.

(b)(1), (b)(3)

Hardtack -- A nuclear series of 72 tests. Hardtack I was held at the Pacific Proving Grounds from April 28 to August 18, 1958. The decision to declare a moratorium on testing resulted in Hardtack II, held at the Nevada Test Site between September 12 and October 30, 1958.

Hydrostat -- A pressure switch which closes at a prescribed water depth.

Inertial Switch -- A switch containing a small weight and a spring. When subjected to an external force of acceleration or deceleration, the weight compresses the spring. Generally, a metering device is added to measure the length of time the external force is applied.

Initiator -- A source of neutrons.

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Pullout Switch -- A switch whose contacts are kept separated by insertion of some nonconducting material. Release of the bomb from an aircraft results in closure of the switch contacts.

Radar -- Named for Radio Detecting and Ranging. Radars emit a pulse of high-frequency energy and measure the time lapse from that transmission to receipt of a reflected electrical "echo" from an object. This time measurement determines the distance of the object from the transmitting antenna of the radar.

Redwing -- A full-scale nuclear series of 17 tests held at the Pacific Proving Grounds from May 4 to July 21, 1956.

Reservoir -- As used in this history, a container for deuterium-tritium boosting gas.

Retarded Bomb -- A bomb provided with some means for slowing the rate of descent, generally a parachute.

Retrofit -- To modify a weapon, i.e., "retroactively outfit" it with changed material.

Ribbon Parachute -- A parachute having a set of ribbons in place of a solid canopy. This type of parachute provides less severe deceleration on deployment.

Ricochet -- A glancing rebound of a missile when it strikes a target.

Safe-Separation Time -- A time interval provided by a timer to allow safe escape of an aircraft delivering a weapon before the weapon detonates.

Safing -- Putting a weapon in condition such that it cannot fire.

Services -- The Department of Defense.

Squib -- A device containing a small powder charge. When detonated, the resulting gas pressure closes a switch or performs a similar action. A light, quick-acting, one shot device.

(b)(3)

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